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<b>14. ABSTRACT</b> Blast Injury is a significant source of casualties in current NATO operations and the spectrum of blast injuries and their consequences is broad. To address the research issues posed by the wide spectrum of battle injuries will require a multidisciplinary approach. The Symposium focused on the multi-disciplinary science that provides the foundation to increase our understanding of blast injury from four perspectives: 1) defining the problem; 2) studying blast injury mechanisms; 3) studying blast-induced head injury; and, 4) mitigating blast injury. Significant contributions realized from this Symposium are in five areas. First is that blast injury will require a disciplined research approach to the "toxicology of blast". Second is the need for physics-based modeling of primary blast injury. Third was the appreciation that the establishment of common animal models of injury will be essential to research progress. Fourth is the pressing need for scientific understanding of non-penetrating blast injuries to the brain which are manifest in a host of symptoms whose etiology is at best vague. And the fifth is the excellent reference source for researchers derived from the extensive bibliographies that are included in the technical papers. The Symposium was successful in providing a timely and successful venue framing a future for NATO Research and Technology work on blast injury.					
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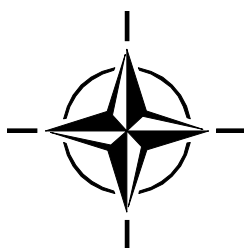
**RTO MEETING PROCEEDINGS**

**MP-HFM-207**

# **A Survey of Blast Injury across the Full Landscape of Military Science**

(Etude d'ensemble des blessures dues aux explosions  
à travers le panorama complet de la science militaire)

Papers presented at the RTO Human Factors and Medicine Panel (HFM)  
Symposium held in Halifax, Canada on 3 – 5 October 2011.



Published October 2011

# The Research and Technology Organisation (RTO) of NATO

RTO is the single focus in NATO for Defence Research and Technology activities. Its mission is to conduct and promote co-operative research and information exchange. The objective is to support the development and effective use of national defence research and technology and to meet the military needs of the Alliance, to maintain a technological lead, and to provide advice to NATO and national decision makers. The RTO performs its mission with the support of an extensive network of national experts. It also ensures effective co-ordination with other NATO bodies involved in R&T activities.

RTO reports both to the Military Committee of NATO and to the Conference of National Armament Directors. It comprises a Research and Technology Board (RTB) as the highest level of national representation and the Research and Technology Agency (RTA), a dedicated staff with its headquarters in Neuilly, near Paris, France. In order to facilitate contacts with the military users and other NATO activities, a small part of the RTA staff is located in NATO Headquarters in Brussels. The Brussels staff also co-ordinates RTO's co-operation with nations in Middle and Eastern Europe, to which RTO attaches particular importance especially as working together in the field of research is one of the more promising areas of co-operation.

The total spectrum of R&T activities is covered by the following 7 bodies:

- AVT Applied Vehicle Technology Panel
- HFM Human Factors and Medicine Panel
- IST Information Systems Technology Panel
- NMSG NATO Modelling and Simulation Group
- SAS System Analysis and Studies Panel
- SCI Systems Concepts and Integration Panel
- SET Sensors and Electronics Technology Panel

These bodies are made up of national representatives as well as generally recognised 'world class' scientists. They also provide a communication link to military users and other NATO bodies. RTO's scientific and technological work is carried out by Technical Teams, created for specific activities and with a specific duration. Such Technical Teams can organise workshops, symposia, field trials, lecture series and training courses. An important function of these Technical Teams is to ensure the continuity of the expert networks.

RTO builds upon earlier co-operation in defence research and technology as set-up under the Advisory Group for Aerospace Research and Development (AGARD) and the Defence Research Group (DRG). AGARD and the DRG share common roots in that they were both established at the initiative of Dr Theodore von Kármán, a leading aerospace scientist, who early on recognised the importance of scientific support for the Allied Armed Forces. RTO is capitalising on these common roots in order to provide the Alliance and the NATO nations with a strong scientific and technological basis that will guarantee a solid base for the future.

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# A Survey of Blast Injury across the Full Landscape of Military Science

(RTO-MP-HFM-207)

## Executive Summary

Blast injury is a significant source of casualties in current NATO operations. The term “blast injury” creates considerable confusion in military medicine. Simply stated, “blast injury” includes the entire spectrum of injuries that can result from exposure to an explosion. The spectrum of blast injuries and their consequences is broad. To address the research issues posed by the wide spectrum of battle injuries will require a multi-disciplinary approach. The Symposium focused on the key aspects of multi-disciplinary science and medicine that would provide the necessary foundation to increase our understanding of blast injury. Six symposium sessions addressed the Programme Committee’s four key themes:

- 1) Defining the Problem;
- 2) Studying Blast Injury Mechanisms;
- 3) Studying Blast-Induced Head Injury; and
- 4) Mitigating Blast Injury.

The Symposium was successful in providing a timely and successful venue that sets a framework for future NATO Research and Technology work. In addition, it has provided an initial compendium of research progress that can be used as a reference source for other NATO organizations such as the Conference of National Armaments Directors (CNAD) and the Committee of the Chiefs of Military Medical Services in NATO (COMEDS).

The Symposium’s Programme Committee initially set three goals for this technical activity:

- 1) Increase the understanding of blast injury in military operations;
- 2) Explore and describe the range of blast injuries seen in current NATO operations; and
- 3) Delineate some of the medical treatment strategies currently being employed by NATO medical personnel.

These three goals had adequate treatment by the portfolio of technical presentations offered and the discussions that ensued. A fourth goal was imbedded in the selection of papers for the Symposium and in its title – engaging a multi-disciplinary scientific dialog via a “survey” of current research. This fourth goal was clearly met both by the diversity of science presented and active cross-disciplinary discussions that emerged.

The significant and new contributions realized from this Symposium are manyfold. First is the emergence of an understanding that blast injury will require a disciplined research approach which this reviewer termed “the toxicology of blast”. Second is the beginning of dialog on the need for physics-based modeling of primary blast injury for the current blast scenarios. Third was the appreciation that research on and establishment of animal models of injury will be a key in the development of the medical sciences base for injury treatments. Fourth is in the area of the great and pressing need for scientific understanding of non-penetrating blast injuries to the brain which are manifest in a host of symptoms whose etiology is at

best vague. And a fifth area is derived from the extensive bibliographies that are included in the technical papers. These bibliographies can be used as an excellent way to achieve an immersion into the history and technical challenges posed by blast injury.

Taken in aggregate, this Symposium presented information that is timely and should allow NATO, in the near future, to advance the state-of-practice in military medicine by initiating new elements in the Program of Work of the HFM Panel and by engaging an active dialog with COMEDS on approaches to the translation of the science into best medical practice. The impetus generated by this Symposium should be continued in the form of one or more new task groups and/or workshops to address, at a minimum:

- 1) Methods for blast incident reconstruction and analysis where medical and human factors data can be developed to inform new protection technology development; and
- 2) A toxicological approach to blast inclusive of mechanisms of dose (e.g., shock tube exposure standards), delineation of dose-response endpoints, and common research animal models of blast injury.

The HFM Panel was encouraged to expediently develop one or more Technical Activity Proposals (TAP) to address the immediacy of gaining a greater understanding of blast injury mechanisms, diagnosis and treatments.

# **Etude d'ensemble des blessures dues aux explosions à travers le panorama complet de la science militaire**

## **(RTO-MP-HFM-207)**

### **Synthèse**

Les blessures par souffle font un nombre important de victimes dans les opérations actuelles de l'OTAN. L'expression « blessure par souffle » crée une grande confusion dans la médecine militaire. En termes simples, la « blessure par souffle » couvre tout le spectre des blessures pouvant provenir de l'exposition à une explosion. Ce spectre est large et inclut une palette de conséquences étendue. Traiter les thèmes de recherche dus au large spectre des blessures de guerre exigera une approche multidisciplinaire. Le symposium s'est concentré sur les aspects essentiels de la science et de la médecine multidisciplinaires qui fourniraient les bases nécessaires à l'amélioration de notre compréhension des blessures par souffle. Six sessions ont abordé les quatre thèmes fondamentaux identifiés par le comité d'organisation, qui étaient les suivants :

- 1) Définition du problème ;
- 2) Etude des mécanismes des blessures par souffle ;
- 3) Etude des blessures à la tête induites par le souffle ; et
- 4) Atténuation des blessures par souffle.

Le symposium est parvenu à proposer un cadre adapté qui établit le contexte des futurs travaux de recherche et technologie de l'OTAN. De plus, il a fourni un recueil initial sur les avancées de la recherche qui peut servir de référence aux autres organisations de l'OTAN, notamment la Conférence des directeurs nationaux des armements (CDNA) et le Comité des chefs des services de santé militaires au sein de l'OTAN (COMEDS).

Le comité d'organisation du symposium a assigné trois objectifs à cette activité technique, à savoir :

- 1) Améliorer la compréhension des blessures par souffle dans les opérations militaires ;
- 2) Etudier et décrire la palette des blessures par souffle dans les opérations actuelles de l'OTAN ; et
- 3) Décrire les stratégies de traitement médical actuellement employées par le personnel médical de l'OTAN.

Ces trois objectifs ont été traités de façon appropriée au travers des exposés techniques proposés et pendant les discussions qui s'en sont suivies. Un quatrième objectif ressortait de la sélection des articles pour le symposium et de son intitulé : engager un dialogue scientifique multidisciplinaire par le biais d'une « étude » des recherches actuelles. Ce quatrième objectif a clairement été atteint au regard de la diversité des sciences présentées et des discussions interdisciplinaires animées qui ont eu lieu.

Les apports de ce symposium sont significatifs à bien des égards. Premièrement, on commence à comprendre que les blessures par souffle nécessiteront une démarche de recherche disciplinée, que le présent rédacteur qualifie de « toxicologie du souffle ». Deuxièmement, un dialogue s'est amorcé sur la nécessité d'une modélisation physique des principales blessures par souffle pour les scénarios d'explosion actuels. Troisièmement, il apparaît que la recherche sur les modèles de blessure aux animaux et l'établissement de ces modèles seront essentiels au développement de la base scientifique médicale de traitement des blessures.

Quatrièmement, les blessures non pénétrantes par souffle touchant le cerveau, qui se manifestent par une foule de symptômes dont l'étiologie est au mieux vague et qu'il est urgent de comprendre au niveau scientifique, ont fait l'objet de contributions très intéressantes. Cinquièmement, les bibliographies complètes incluses dans les articles techniques sont un excellent moyen de se plonger dans l'histoire et dans les défis techniques que représentent les blessures par souffle.

Dans son ensemble, le symposium a présenté des informations opportunes qui devraient permettre à l'OTAN, dans un futur proche, de faire progresser l'état de la pratique en médecine militaire, en apportant de nouveaux éléments au programme de travaux de la Commission sur les facteurs humains et la médecine et en engageant un dialogue actif avec le COMEDS sur la manière de traduire la science en meilleure pratique médicale. L'élan généré par ce symposium devrait être entretenu sous la forme d'un ou plusieurs groupes de travail et/ou ateliers, afin d'aborder, tout au moins :

- 1) Les méthodes de reconstruction et d'analyse des incidents d'explosion, lorsque des données médicales et sur les facteurs humains peuvent être développées pour nourrir le développement de nouvelles technologies de protection ; et
- 2) Une approche toxicologique du souffle incluant les mécanismes de dose (par exemple, normes d'exposition à un tube à choc), la description des points limites dose-réponse et les modèles animaux de recherche courants pour les blessures par souffle.

La Commission sur les facteurs humains et la médecine a été encouragée à développer de manière opportune une ou plusieurs propositions d'activité technique (TAP) permettant d'acquérir dans l'immédiat des connaissances sur les mécanismes, le diagnostic et les traitements des blessures par souffle.